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ROLE OF ENVIRONMENTAL FACTORS IN THE DEVELOPMENT OF CHRONIC LUNG DISEASE IN SMOKING AND NON-SMOKING ADOLESCENTS

PROGRESS REPORT

NOVEMBER 15, 1983

URBAN AIR ENVIRONMENT GROUP

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TO

National Health Research and
Development Programme
Health and Welfare Canada
Project 6606-2107-53

Ontario Ministry of Health
Policy Development and
Research Branch
Public Health Grant CHS-R64

ROLE OF ENVIRONMENTAL FACTORS IN THE DEVELOPMENT OF CHRONIC LUNG DISEASE IN SMOKING AND NON-SMOKING ADOLESCENTS

PROGRESS REPORT

NOVEMBER 15, 1983

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PART 1

INTRODUCTION

This Progress Report has been prepared to accompany our 1983 grant applications to the Ontario Ministry of Health and to Health and Welfare Canada's National Health Research and Development Programme. It covers the period from 1982-07-01 to 1983-09-30.

Reference is made in this report to our previous study, which provides the data base on which the present study rests. The former study, referred to as the "School Children's Study", ran from 1978-06-01 to 1982-06-30; its Final Report was titled: "The Hamilton Study: The Effects of Environmental Factors on the Respiratory Health of School Children."

PART I

INTRODUCTION

PART 2

EPIDEMIOLOGICAL MONITORING

2.1 PROGRESS OF TESTING

Testing the children was recommenced in December 1982. The initial plan described how, in the original grant application proposal, only the children with birth years 1969 and 1971 would be tested in each school entered during the "first round". By the end of the school year in June 1983, 807 children had been tested, at an average rate of 20 subjects per day. Tables 2-1 to 2-4 detail the characteristics of these children.

2.1.1 CHANGES IN METHOD

The method of testing has been altered slightly from the original proposal. The major difference is due to the present unavailability of the necessary software for the on-line display and recording of flow-volume loops directly onto disc prior to data transmission to and storage at McMaster. Because of this, the variables which are recorded from the forced expired manoeuvre are transcribed by the pulmonary function tester onto the appropriate forms at the time of testing, and are also later coded by her. This procedure is working satisfactorily at present.

PART 2

EPIDEMIOLOGICAL MONITORING

2.1. PROGRESS OF TESTING

Testing the children was recommenced in December 1982. The initial plan described here, is the original grant application proposal, only the children with birth years 1980 and 1971 would be tested in each school entered during the "first round". By the end of the school year in June 1987, 807 children had been tested, at an average rate of 20 subjects per day. Tables 2-1 to 2-4 detail the characteristics of these children.

2.1.1 CHANGES IN METHOD

The method of testing has been altered slightly from the original proposal. The major difference is due to the present unavailability of the necessary software for the on-line display and recording of flow-volume loops directly onto disc prior to data transmission to and storage at MedAster. Because of this, the variables which are recorded from the forced expired manoeuvre are transcribed by the pulmonary function tester onto the appropriate forms at the time of testing, and are also later coded by hand. This procedure is working satisfactorily at present.

Developments in hardware have allowed us to purchase equipment which will allow for display of flow-volume loops during the next school year. Coding of questionnaire data is also performed on site by the pulmonary function technician.

2.2 MAINTENANCE OF THE COHORT

We have sought consent from the parents of each child studied during the final year of our "School Children's Study" project (1981/82). This consent is intended to cover the five-year design length of the present study. Of the total of 2682 children who were available from the previous study, 2137 children had consent given for them by the end of June 1983. When the tester is in the school itself, parents of children for whom consent has not yet been given are approached again; this has resulted in an average yield of 46% of the outstanding consents in schools that we have so far entered. Thus we expect to achieve the sample size of 2000 that was justified in the original grant application.

In our 1981 application, 3440 was mentioned as the total number of children from which the cohort could be drawn. However, attrition over the two years since that application has reduced that number to 2682, from which our present sample is drawn.

2.3 FUTURE TESTING OF COHORT

Based upon our pulmonary function testing experiences from 1982-12

those children who have commenced smoking during the course of the study. To this end, the children complete a questionnaire about their own smoking (Appendix 2-2). The results from this questionnaire for the children tested during the last school year (1982-12/83-06) are shown in Table 2-5. The results are consistent with those obtained in the survey performed by Brown (1980). Following Brown's figures, we expect that 20% of the cohort will be smoking by the time the study is completed.

Table 2-6 shows the results of the analysis for carbon monoxide of expired breath samples, the method of questionnaire response validation which we are using. This is a limited method of validation by itself, in that it will pick out only those children who have been smoking in the two to three hours prior to the test. Therefore, it may be able to pin-point a number of the false negative responses, if they in fact exist.

Table 2-6 shows a clear increase in carbon monoxide level in those children who have begun to smoke regularly (that is, more than one cigarette per week), with the highest level being seen in the heaviest smoking category. No levels above 10 ppm were seen in the "Never smoked" or "Less than one cigarette per week" categories. We feel that this relationship between carbon monoxide levels and smoking category by questionnaire response provides concurrent criterion validation for these responses.

TABLE 2-1

SAMPLE CHARACTERISTICS

SEX

	NUMBER	RELATIVE FREQUENCY (%)
MALE	416	51.5
FEMALE	391	48.5
TOTAL	807	100.0

AGE

11	241	29.9
12	108	13.4
13	361	44.7
14	97	12.0
	807	100.0

TABLE 2-2

SAMPLE CHARACTERISTICS
PREVALENCE OF RESPIRATORY SYMPTOMS

SYMPTOM	YES (%)	NO (%)	MISSING (%)	N/A (%)*	TOTAL (%)
MORNING COUGH	134 (16.6)	652 (80.8)	21 (2.6)	-	807 (100.0)
DAY/NIGHT COUGH	191 (23.7)	595 (73.7)	21 (2.6)	-	807 (100.0)
CHEST WHEEZY EVER	190 (23.5)	596 (73.9)	21 (2.6)	-	807 (100.0)
CHEST WHEEZY OFTEN	38 (4.7)	152 (18.8)	21 (2.6)	596 (73.9)	807 (100.0)
ASTHMA EVER	78 (9.7)	708 (87.7)	21 (2.6)	-	807 (100.0)
ASTHMA IN LAST YEAR	43 (5.3)	35 (4.3)	21 (2.6)	708 (87.7)	807 (99.9)
COUGH WITH COLD	673 (83.4)	113 (14.0)	21 (2.6)	-	807 (100.0)

*Not applicable due to branching in questions on wheezing and asthma.

TABLE 5.1

OBSERVED CHARACTERISTICS
SHORT DISTANCE OF DESCRIPTIVE STATISTICS

TABLE 2-3

SAMPLE CHARACTERISTICS
DOMESTIC ENVIRONMENT

	YES (%)	NO (%)	MISSING (%)	N/A (%)	TOTAL (%)
MOTHER SMOKE	305 (37.8)	477 (59.1)		4 (0.5)	807 (100.0)
FATHER SMOKE	353 (43.7)	398 (49.3)	21 (2.6)	35 (4.3)	807 (99.9)
GAS COOKING	130 (16.1)	656 (81.3)	21 (2.6)	-	807 (100.0)

TABLE 2-4

SAMPLE CHARACTERISTICS

PULMONARY FUNCTION MEASUREMENTS

VARIABLE	NUMBER	MISSING	MEAN, SD	MIN	MAX
FVC	785	22	3.15, 0.64	1.81	5.61
FEV1	785	22	2.55, 0.58	1.27	4.22
FEF 25-75	785	22	2.84, 0.80	0.43	5.45
FEF 75-85	785	22	1.15, 0.45	0.12	3.09
PF	785	22	5.05, 1.11	2.42	9.11
MEF50	785	22	3.26, 0.92	0.52	6.12
MEF75	785	22	1.51, 0.55	0.17	3.39
MET	785	22	0.61, 0.35	0.28	6.35

TABLE S-4

SAMPLE CHARACTERISTICS

CHARACTERISTICS OF SAMPLED HOUSEHOLDS

AVAILABILITY	NAME	MEAN	MEDIAN	MODE	MIN	MAX	RANGE	VARIANCE	SUM
AVC	AVERAGE CHILDREN	1.2	1.0	0	0	5	5	1.4	2.4
AVH	AVERAGE HOUSEHOLD SIZE	3.4	3.0	2	1	7	6	2.3	6.8
AVI	AVERAGE INCOME	$12,400.00	$11,000.00	$7,000.00	$1,000.00	$25,000.00	$24,000.00	$49,000,000.00	$24,800.00
AVW	AVERAGE WORKERS	1.7	1.5	1	0	3	3	0.6	3.4
FEL	FEMALE LABOR FORCE	1.1	1.0	0	0	2	2	0.6	2.2
MEL	MALE LABOR FORCE	1.1	1.0	1	0	2	2	0.3	2.2
NCI	NUMBER CHILDREN	2.4	2.0	2	0	5	5	1.4	4.8

TABLE 2-5

SMOKING HABITS BY QUESTIONNAIRE

SMOKING CATEGORY*	NUMBER	RELATIVE FREQUENCY (%)
NEVER SMOKED	478	59.2
SMOKED LESS THAN 1/WEEK	256	31.8
SMOKED 1-10/WEEK	33	4.1
SMOKED 11-20/WEEK	16	2.0
MISSING	24	3.0
TOTAL	807	100.1

*Categories are mutally exclusive.

TABLE 2-6

VALIDATION OF SMOKING QUESTIONNAIRE
SMOKING CATEGORY VS. EXPIRED CARBON MONOXIDE ANALYSIS

SMOKING* CATEGORY	NUMBER	MEAN CO DIFF**	95% CONFIDENCE LIMITS FOR MEAN
NEVER SMOKED	478	2.00	1.92 - 2.09
SMOKED LESS THAN 1/WEEK	256	2.08	1.91 - 2.20
SMOKE 1-10/WEEK	33	2.94	2.21 - 3.66
SMOKED 11-20/WEEK	16	9.50	5.15 -13.85
TOTAL	783***	2.22	2.09 - 2.36

* Categories are mutually exclusive. Units; cigarettes per week.

** Difference in ppm between ambient CO and expired CO.

*** The 24 missing cases have been left out of this table.

PART 3

AIR QUALITY MEASUREMENTS

3.1 PARTICULATES

3.1.1 TSP MEASUREMENTS

We have measured TSP levels across the city of Hamilton continuously since 1978, when we began our "School Children's Study" project. In July 1981, when we made our first application for funding of our current project, our TSP sampling network was made up of 17 high-volume (hi-vol) samplers. We attempted to reduce the size of this network by step-wise analysis of predicted exposure values derived from our response surface modelling procedure. Using seasonal data, we determined which sampling site would have the least influence on the network results, removed its data from the analysis, and proceeded again to identify the next location until 8 samplers were removed. Unfortunately, this process showed that the most "removable" sites differed from season to season. Indeed, even the most consistent sites appeared on only three out of the four seasonal lists, and then with different rankings. In spite of this lack of complete consistency, we did feel justified in removing three of these sites. However, to operate with a further-reduced number of

PART I

AIR QUALITY MEASUREMENTS

1.1 PARTICULATES

1.1.1 TSP MEASUREMENTS

samplers would at any one time have required activating and de-activating sites on a 3-monthly basis, which ultimately would have been more labour-intensive than maintaining all sites active during the year. Since our exposure calculations are based on monthly averages, it is necessary to maintain the network in its present configuration of 14 sites. This has proven to add little to the burden of operating the network except for a small increase in weighing and data entry time. Data from our TSP network are presented in Appendix 3-1 in the form of monthly geometric means.

3.1.2 PSD SAMPLING

Our 9-site PSD sampling network has a history similar to that of our TSP network. However, we have maintained its size as its coverage of the area is thinner. Data from this network are presented in Appendix 3-2 as monthly average Mass Median Diameters.

3.2 INDOOR AIR QUALITY MONITORING

Presently, no funds are available for indoor air quality monitoring, so our team of 4 experienced technicians has been disbanded and are now in search of other employment. The results of this study are summarized in Appendix 3-3.

3.3 SULPHUR DIOXIDE MONITORING

In 1977, we carried out a pilot study in preparation for our "School Children's Study" project. During this study, we used the Beckman 906A sulphur dioxide monitor to collect a portion of our air quality data. At that time, the instrument was in constant use by the Ontario Ministry of the Environment, and was still actively sold and supported by Beckman, though new SO2 monitoring technology was being introduced. However, Beckman suspended production of the 906A during 1979, and discontinued its support from Toronto during June of 1983.

Following the pilot study, we designed the "School Children's Study" project to make use of the Beckman 906A, which was to be calibrated against, and eventually replaced by, the Laser Absorption Spectrometer (LAS) being developed by McMaster's Department of Engineering Physics, under Dr. J. Shewchun (later replaced by Dr. B. Garside). This Engineering Physics laser group was responsible for collection of the SO2 data, as well as for the development of the LAS. When approval was received for the "School Children's Study" project (in November of 1978), those responsible for SO2 data collection were to begin monitoring with those 906A's available, followed by the LAS's to complete the network and to keep the 906A's closely calibrated. Unfortunately, the laser group was not able to develop the LAS to the point where it could be operated unattended; thus, at the end of the study we were left with no LAS's. However, with the assistance of the

3.2 SULPHUR DIOXIDE MONITORING

Ontario Ministry of the Environment, we had sufficient Beckman 906A's to fill our network requirements for the present study.

Sulphur dioxide monitoring was terminated by the Engineering Physics group during December 1981, as the data gathering phase of that project was ending, and the one technician who had been maintaining the SO2 network was leaving. From December 1981, until approval of funding for our present study was received from Health and Welfare Canada (in September 1982), all of the Beckman 906A analyzers used by the laser group were in storage, with the recorders being used for other purposes in the interim.

Since September of 1982, we have worked diligently at putting back into operation the single Beckman Model 953 and as many of the Beckman 906A SO2 Analyzers inherited from the Engineering Physics laser group as possible. During this time we have also, again through the kind assistance of the Ontario Ministry of the Environment, obtained a number of other 906A's on extended loan. Many of these would have required considerable repair before they could be placed in the field; accordingly, we are using them as sources of spares for the five we have thus far been able to return to running order.

Our single technician working on the sulphur dioxide monitoring network is fully involved with servicing the instruments we have been able to put into the field, and with attempting to repair others. This is a never-ending task, as we are reaching the end

of the effective life of many of the electronic components in the Beckman 906A. Some concept of the magnitude of the task of reconditioning our Beckman 906A's may be obtained from the following list of repairs or procedures which had to be carried out for each instrument at the minimum:

1. Cleaning each detector cell with acid;
2. Replacement of detector cell electrodes;
3. Replacement of all internal sample line tubing;
4. Cleaning of inlet selector switches;
5. Cleaning of each flow meter;
6. Replacement of electronic components in the range switch and on the amplifier and water addition printed circuit boards, in order to meet instrument specifications;
7. Replacement of each selective scrubber. Replacement scrubbers used had been stored by Beckman for a considerable time, causing a reduction in instrument response time even with these "new" scrubbers; and
8. The installation of in-line filters to remove particulate matter from the sample gas stream.

As mentioned, one Beckman 953 SO2 monitor was obtained during 1979. When we obtained this instrument from storage, we found that the following parts had to be repaired or replaced: the interferent reactor heater, the temperature control board for the reactor heater, the amplifier board, the fluorescence reaction

chamber, the photomultiplier tube, and some of the lenses in the light collimator, plus the usual replaceable scrubbers. As of this date, the Beckman 953 is still not operational due to the cost of replacing some of the parts.

We have had two SO2 analyzers operational in two upper city locations and have been collecting data from them since March 1983. In addition, the MOE operates two SO2 analyzers in the lower city, so that we currently have SO2 data from four locations in the city, including the MOE sites. Two more analyzers are currently being installed in the field; by December 1983 we hope to have data from a total of 6 locations in the city. Owing to the priority of getting instruments functional and on location, the graphic records of SO2 data generated by our analyzers, although properly calibrated, zero checked, and annotated for time and location, have not yet been reduced. A data management and quality control scheme has been designed and implemented, and is currently ready for data entry.

PART 4

PUBLICATIONS AND PRESENTATIONS

4.1 PUBLICATIONS: PEER-REVIEWED

The following paper will be submitted for publication to the journal indicated before the end of 1983-12, where it will be peer-reviewed according to the journal's standard practices. This paper is based on the epidemiological study with which we have been involved since 1978.

Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, and E.E. Inman "The Hamilton Study: Distribution of Factors Confounding the Relationship Between Air Quality and Respiratory Health". To be submitted to the Journal of the Air Pollution Control Association for publication; for text, see Appendix 4-1.

4.2 PLANNED PEER-REVIEWED PUBLICATIONS

The following is the first group of papers planned concerning the epidemiologic, pulmonary function, and air quality aspects of this study. Accompanying each title is the name of the journal to which each is to be submitted and the estimated month of

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PUBLICATIONS AND PRESENTATIONS

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The following is the first group of papers planned concerning the epidemiologic, pulmonary function, and air quality aspects of this study. Accompanying each title is the name of the journal to which each is to be submitted and the estimated month of

submission.

1. The Hamilton Study: The Role of Environmental Factors in the Respiratory Health of School Children. [The New England Journal of Medicine.] Estimated date of submission: 1984-01.

2. The Hamilton Study: A Three-Year Cohort Study of the Role of Environmental Factors in the Respiratory Health of Children. Epidemiologic Survey Design and Methods. [Journal of Clinical and Investigative Medicine, or American Review of Respiratory Disease.] Estimated date of submission: 1984-02.

3. The Hamilton Study: A Three-Year Cohort Study of the Role of Environmental Factors in the Respiratory Health of Children. Air Quality Measurement Design and Methods. [Journal of the Air Pollution Control Association.] Estimated date of submission: 1984-03.

4. The Hamilton Study: Questionnaire and Lung Function Measurement Quality Control. [American Review of Respiratory Disease, or American Journal of Epidemiology.] Estimated date of submission: 1984-03.

5. The Hamilton Study: Air Pollution Measurement Quality Control. [Journal of the Air Pollution Control Association.] Estimated date of submission: 1984-04.

6. The Hamilton Study: A Comparison of the Single-Breath and Multiple-Breath Nitrogen Washout with the Forced Vital Capacity Manoeuvres as Survey Tools for Use with Children. [American Review of Respiratory Disease.] Estimated date of submission: 1984-04.

4.3 PUBLICATIONS: NON-PEER-REVIEWED

The first of these publications is our Pilot Study report, submitted to Health and Welfare Canada:

1. Kerigan, A.T., G. Gschwandtner, L.D. Pengelly, E.A. Ballik, B.K. Garside and J. Shewchun (1977), "Results of a Pilot Study on the Effects of Suspended Particulates and Sulphur Dioxide on the Respiratory Health of School Children". Report to Health and Welfare Canada on Project 606-1374-40; September 1977.

The following publications were submitted as progress reports to

Health and Welfare Canada (on Project 6606-1752-53) and to the Ontario Ministry of the Environment, Air Resources Branch (on Project 78-020-33):

2. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and J. Shewchun (1979a), "The Effect of Environmental Factors on the Respiratory Health of School Children in Hamilton--Current Report #1, March 1, 1979".

3. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and J. Shewchun (1979b), "The Effect of Environmental Factors on the Respiratory Health of School Children in Hamilton--Current Report #2, October 1, 1979".

4. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and B.K. Garside (1980a), "The Effect of Environmental Factors on the Respiratory Health of School Children in Hamilton--Current Report #3, April 1, 1980". 2 Volumes.

The next three publications in this Section were submitted to Health and Welfare Canada and the Ontario Ministry of the Environment (as mentioned previously), and to the Ontario Ministry of Health (on Public Health Grant CHS-R34):

5. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and B.K. Garside (1980b), "The Effect of Environmental

Factors on the Respiratory Health of School Children in Hamilton--Current Report #4, October 1, 1980". 2 Volumes.

6. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and B.K. Garside (1981a), "The Effect of Environmental Factors on the Respiratory Health of School Children in Hamilton--Current Report #5, April 1, 1981".

7. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith and B.K. Garside (1981b), "The Effect of Environmental Factors on the Respiratory Health of School Children in Hamilton--Current Report #6, October 1, 1981". 2 Volumes.

Copies of the preceding reports are available upon request.

Additionally, the following Master's Thesis was prepared using data from this study:

8. Kerigan, A.T. (1982), "An Index of Respiratory Disease in Children for Environmental Studies". An M.Sc. Thesis in the Design, Measurement and Evaluation Programme, submitted to the School of Graduate Studies, McMaster University, December 1982.

The final report of the "School Children's Study" project has been submitted to the three granting agencies mentioned previously. The full report (1., following) was submitted to these agencies and to selected individuals and groups, while a summary report (2., following) was sent to other individuals and groups.

1. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith, and B.K. Garside (1983), "The Hamilton Study: The Effect of Environmental Factors on the Respiratory Health of School Children. Final Report. June 30, 1983". 2 Volumes.

2. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith, and B.K. Garside (1983), "The Hamilton Study: The Effect of Environmental Factors on the Respiratory Health of School Children. Final Report--Summary Version. June 30, 1983".

Lists of those to whom these reports were sent are given in Appendix 4-2.

4.4 PRESENTATIONS

The following is a list of the presentations which have resulted from this study and from the "School Children's Study", as well as our Indoor Air Quality study, to November 1983.

1. Inman, E. (1980), "Evaluation of the Acquisition and Validity of the NWs Test". Presented at the Annual Meeting of the Canadian Society of Cardiovascular and Pulmonary Function Technologists, at Hamilton, Ontario, September 1980.

2. Pengelly, L.D., A.T. Kerigan, and S.R. Leeder (1980), "Discriminatory Power of Pulmonary Function Tests in Children". Presented to the Fall Meeting of the American Physiological Society, Toronto, Ontario, October 1980.

3. Garside, B.K., C.H. Goldsmith, A.T. Kerigan, L.D. Pengelly (1981), "Air Quality and Its Affect on the Respiratory Health of School Children: A Study in Hamilton, Ontario. 1978-1981". Presented at Environmetrics '81, a meeting co-sponsored by the Society for Industrial and Applied Mathematics (SIAM), and USEPA; held in Alexandria, Virginia, in April 1981.

4. Kerigan, A.T., L.D. Pengelly, C.H. Goldsmith (1981), "Airflow Obstruction in Children and Its Relationship to Questionnaire Data". Presented at the Annual Meeting of the American Thoracic

Society, Detroit, Michigan, in May 1981.

5. Kerigan, A.T., B.K. Garside, C.H. Goldsmith, L.D. Pengelly (1981), "Air Quality and Its Affect on the Respiratory Health of School Children: A Study in Hamilton, Ontario. 1978-1981". Presented at the Annual Meeting of the American Thoracic Society, in Detroit, Michigan, in May 1981.

6. Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, B.K. Garside (1981), "Effects of the Breathing Environment on the Respiratory Health of School Children in Hamilton, Ontario". Presented at the Ontario Ministry of the Environment's 28th Ontario Industrial Waste Conference, in Toronto, Ontario, June 1981.

7. Pengelly, L.D., A.T. Kerigan, E.M. Inman (1981), "Single-Breath Nitrogen Washout as an Epidemiological Survey Tool in Children". Presented at the Annual Meeting of the Canadian Lung Association, in Saskatoon, Saskatchewan, June 1981.

8. Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, W. Furlong, W. Spurgeon, S. Toplack (1981), "A Multipollutant Sampler for Indoor and Outdoor

Ambient Air". Presented at the International Symposium on Indoor Air Pollution, Health and Energy Conservation, sponsored by Harvard University, John F. Kennedy School of Government and School of Public Health, with a number of other organizations; held at Amherst, Massachusetts, October 1981.

9. Inman, E. (1981), "A Comparison of the Forced Vital Capacity Manoeuvre with the Multiple-Breath Nitrogen Wash-Out as a Tool for Measuring Pulmonary Function in an Epidemiological Study Involving Children Aged 7 to 14 Years". Presented at the Annual Meeting of the Canadian Society of Cardiovascular and Pulmonary Function Technologists, at Niagara-on-the-Lake, Ontario, October, 1981.

10. Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, B.K. Garside (1981), "The Hamilton Study: Effect of the Breathing Environment on the Respiratory Health of Children". Presented at the Ontario Ministry of the Environment's Technology Transfer Conference No. 2, in Toronto, Ontario, November 1981.

11. Furlong, W., and L.D. Pengelly (1981), "Epidemiological Study". Presentation at the

Ontario Ministry of the Environment, West Central Region, Technical Seminar (in-house), at Hamilton, Ontario, November 1981.

12. Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, S.A. Toplack, W. Furlong (1982), "The Hamilton Study: Spatial Distribution of SO2 and TSP in an Urban Area". Presented at the Joint Annual Conference of the Ontario Section of the Air Pollution Control Association and the Pollution Control Association of Ontario, at Toronto, Ontario, in April 1982.

13. Pengelly, L.D., C.H. Goldsmith, A.T. Kerigan, S.A. Toplack, W.J. Furlong (1982), "The Hamilton Study: Relationships Between Indoor and Outdoor Levels of Sulphur Dioxide, Nitrogen Dioxide, and Particulates in Elementary Schools". Presented as a poster session, Paper 82-17P.3, at the Annual Meeting of the Air Pollution Control Association. New Orleans, LA; 82-06-20/25.

14. Inman, E. (1982), "A Method of Cataloguing Data Analyses Using the Computer-Managed List System on the HP 3000". Presented at the Annual Meeting of the Canadian Society of Cardiovascular and Pulmonary Function Technologists, at Toronto, Ontario, October 1982.

15. Pengelly, L.D., E. Inman, A.T. Kerigan, and C.H. Goldsmith (1982), "Multiple-Breath Nitrogen Washout (NWm) as an Epidemiological Survey Tool in Children". Presented as a poster session at the Annual Meeting of the Canadian Thoracic Society, held at Quebec City, Quebec, during June 1982.

16. Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, and E.E. Inman (1983), "The Hamilton Study: Distribution of Factors Confounding the Relationship Between Air Quality and Respiratory Health". Presented as Paper No. 83-9.9 at the 1983 Annual Meeting of the Air Pollution Control Association, held in Atlanta, GA, 1983-06-19/24.

17. Pengelly, L.D., W. Furlong, C. Goldsmith, and S. Toplack (1983), "The Hamilton Study: Relationship Between Outdoor and Indoor Air Quality in Homes and Elementary Schools". Presented at the 4th Annual Technology Transfer Conference, held in Toronto, Ontario, on 1983-11-29/30, 1983; sponsored by the Research Advisory Committee of the Ontario Ministry of the Environment.

APPENDICES

NUMBER	
2-1	Testing Schedule Projections
2-2	Self-Administered Smoking Questionnaire
3-1	TSP Network Data
3-2	PSD Network Data
3-3	Abstract of Presentation on Indoor Air Quality Study Results
4-1	Draft of Paper to be Submitted to JAPCA
4-2	Distribution List For "School Children's Study" Report

Appendix 2-1

TESTING SCHEDULE PROJECTIONS

PROJECTIONS FOR FALL TESTING

A. Moving through entire cohort at once, testing all birthdates:

Schools: Seq. # 15 - 21	=	640 (no. to test)	÷	20 (*per day)	+	21 (moving & preparation)	=	53.0
Schools: Seq. # 1 - 14	=	729	÷	20	+	42	=	78.4
High Schools:		263	÷	20	+	60	=	73.2
		1632						
TOTAL DAYS to test cohort, including moves							=	204.6

B. Moving through cohort completing children in senior public, and high schools with birthdates in 1969, 1971 and returning to same schools again to test those born in 1968, 1970.

Schools: Seq. # 15 - 21, born in 1969, 1971	= 353	÷	20	+	21	=	38.6
High Schools with birthdates in 1969, 1971	= 145	÷	20	+	60	=	67.2
Schools: Seq. # 1 - 21, born in 1968, 1970	= 907	÷	20	+	63	=	112.8
Seq. #1-14 (those in 69, 71 not tested before)	= 90						
High Schools with birthdates in 1968, 1970	= 118	÷	20	+	60	=	65.9
	*1613						
TOTAL DAYS to test cohort, including moves						=	284.5

CONCLUSION

It will take approximately 205 days to complete the cohort, if all children, regardless of birthdate, are tested from now on.

It will take approximately 284 days to complete the cohort by testing children with 1969 and 1971 birthdates first and then returning to all schools to test children with 1968 and 1970 birthdates.

These estimates allow three days between schools for moving and preparation and are based on a testing rate of 20 per day. Thus optimum conditions are assumed and any problems will make testing time longer. This also assumes that all consents will be obtained.

If all goes as planned and the whole cohort is tested at the same time, it is possible that all children will have been tested by next summer.

*Section B does not take into account 19 children whose birth year was 1972.

TOTAL: 2682

CONSENT: YES 2137

NO 545

BY INDIVIDUAL YEARS:

1968: YES = 110
NO = 55

1969 YES = 675
NO = 150

1970: YES = 687
NO = 223

1971: YES = 649
NO = 112

2661 + 19 records with year = 72
+ 2 records with no birth year
=2682

% tested of total number $\frac{786}{2682}$ = 29.3%

% tested of "yes" consents $\frac{786}{2137}$ = 36.8%

% of "yes" consents to total number $\frac{2137}{2682}$ = 79.7%

RETURNED CONSENT RATE

	OUTSTANDING	RETURNED	
LAWFIELD (#40)	22	15	68.2%
PRINCE OF WALES (#03)	23	12	52.2%
TWEEDSMUIR (#43)	29	15	51.7%
WESTVIEW (#44)	21	19	90.5%
QUEEN MARY (#55)	6	4	66.7%
G. L. ARMSTRONG (#36)	19	6	31.6%
BENNETTO (#45)	11	1	9.1%
ADELAIDE HOODLESS (#41)	2	1	50.0%
NORWOOD PARK (#42)	6	3	50.0%
LAKE AVENUE (#09)	9	4	44.4%
CHEDOKE (#46)	20	8	40.0%
GLENBRAE (#49)	8	3	37.5%
VISCOUNT MONTGOMERY (#33)	14	1	7.1%
HAMPTON HEIGHTS (#38)	18	8	44.4%

AVERAGE RATE OF RETURN OF "NO" CONSENTS = 46.0%

TESTING DONE BY BIRTH YEAR

1968

CONSENT	TESTED: YES	TESTED: NO
YES (110)	2	108
NO (55)	0	55

1969

CONSENT	TESTED	
YES (675)	462	213
NO (150)	0	75

1970

CONSENT	TESTED: YES	TESTED: NO
YES (687)	7	680
NO (223)	0	223

1971

CONSENT	TESTED: YES	TESTED: NO
YES (649)	348	301
NO (112)	0	70

Appendix 2-2

SELF-ADMINISTERED SMOKING QUESTIONNAIRE

SMOKING FORM

IDS

Please complete this form by placing an "X" in the correct box.

No one will know whose form this is. It is a secret.

1. Have you ever smoked?

   If yes, go to Question 2
   If no, go to Question 9

   ☐ YES ☐ NO

   ☐ 36

FOR OFFICE USE ONLY

2. Have you smoked at least 1 cigarette a week for a period of 6 months?

   If yes, go to Question 3
   If no, go to Question 7

   ☐ YES ☐ NO

   ☐ 37

3. How many cigarettes do you usually smoke in a week?

   ☐ 1-10 ☐ 11-20 ☐ more than 20

   ☐ 38

4. At what age did you smoke your first cigarette?

   ☐ 6 ☐ 7 ☐ 8 ☐ 9 ☐ 10 ☐ 11

   ☐ 12 ☐ 13 ☐ 14 ☐ 15 ☐ 16 ☐ 17

   ☐ 18 ☐ 19 ☐ 20 ☐ over 20

   ☐ 39 ☐ 40

5. Do you smoke the same brand if possible?

   ☐ YES ☐ NO

   ☐ 41

PLEASE TURN TO PAGE 2 . . .

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36

37

38

39 40

41

6. If so please fill in and check.

. . . . . .

Brand Name

☐ Low tar (light) ☐ High tar

☐ 42

7. Do you smoke every day?

☐ YES ☐ NO

☐ 43

8. If yes, fill in how many cigarettes you smoke on an average each day?

. . . . . .

☐ ☐ ☐ 44 45 46

9. Does your mother smoke?

☐ YES ☐ NO ☐ CAN'T ANSWER

☐ 47

10. **Not counting your mother or yourself, how many other people smoke at your home?**

☐ 1 ☐ 2 ☐ 3 ☐ more than 3

☐ 48

Appendix 3-1

TSP NETWORK DATA

McMASTER TSP SITES
MONTHLY GEOMETRIC MEANS
(ug/m3)

1982

SITE NUMBER AND NUMBER		MONTHS 01	02	03	04	05	06	07	08	09	10	11	12
MOUNT HOPE	102	-	38	-	-	-	-	-	44	41	32	36	30
UPPER OTTAWA	104	59	35	53	42	61	43	44	31	34	30	31	29
ABERDEEN	106	76	38	71	53	123	67	58	37	36	36	38	31
RED HILL CREEK	109	70	38	57	46	58	43	52	33	31	31	31	34
HIGHVIEW	110	-	-	69	51	85	54	59	44	45	44	47	40
CATHEDRAL GIRLS'	112	60	46	81	63	126	82	68	46	61	54	50	53
McELROY II	113	-	47	87	54	155	82	66	45	47	42	44	36
WESTMOUNT	114	77	40	63	41	100	57	52	33	35	33	37	31
BISHOPSGATE	115	73	40	64	55	-	39	52	35	38	35	35	31
DUNDURN CASTLE	116	55	41	70	49	74	52	61	41	43	38	36	44
M.O.E.	117	82	48	84	67	70	50	70	56	57	46	44	40
WOODWARD	118	70	54	80	72	73	64	73	60	62	66	51	60
WHITNEY II	119	68	44	72	53	94	60	57	34	36	32	38	43
SAN DIEGO II	120	53	34	59	42	91	58	64	35	38	33	35	24
MOUNT ALBION	121	54	50	79	47	84	64	67	43	46	39	41	40
ALBERTON II	122	62	31	48	44	83	49	51	28	36	29	26	27
UPPER WENTWORTH II	123	64	39	75	55	109	65	59	40	46	42	46	37

- = INSUFFICIENT DATA

McMASTER TSP SITES
MONTHLY GEOMETRIC MEANS
(ug/m3)

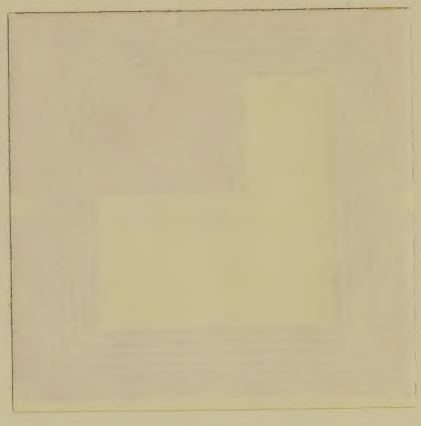
1983

SITE NAME AND NUMBER		MONTHS 01	02	03	04	05	06
MOUNT HOPE	102	35	35	54	43	57	66
UPPER OTTAWA	104	36	35	42	36	41	53
ABERDEEN	106	41	42	57	38	61	71
RED HILL CREEK	109	41	36	42	33	42	55
HIGHVIEW	110	49	52	65	68	57	72
CATHEDRAL GIRLS'	112	54	59	72	68	62	81
McELROY II	113	39	45	65	51	58	69
WESTMOUNT	114	37	37	63	51	48	58
BISHOPSGATE	115	43	37	51	60	47	58
DUNDURN CASTLE	116	49	41	40	31	52	64
M.O.E.	117	-	51	-	-	58	78
WOODWARD	118	58	58	44	48	60	87
WHITNEY II	119	44	41	48	32	50	54
SAN DIEGO II	120	38	29	45	33	53	69
MOUNT ALBION	121	50	44	63	33	64	72
ALBERTON II	122	29	27	36	31	44	53
UPPER WENTWORTH II	123	51	54	76	-	58	67

- = INSUFFICIENT DATA

Appendix 3-2

PSD NETWORK DATA



McMASTER PSD SITES
MONTHLY MASS MEDIAN DIAMETERS
(MICRONS)

1982

SITE NAME AND NUMBER		MONTHS 01	02	03	04	05	06	07	08	09	10	11	12
MOUNT HOPE	201	-	1.9	1.6	3.4	2.8	3.0	3.3	2.8	3.0	-	2.6	2.3
BARTON AND SANFORD	202	2.9	2.3	3.0	3.8	3.4	3.5	3.8	5.1	4.6	3.3	3.7	3.2
NORTH PARK	203	3.8	2.8	2.9	5.5	3.4	3.3	3.7	4.9	2.9	4.4	4.3	3.3
SENECA	204	3.1	1.3	1.5	2.8	2.8	2.9	2.5	2.2	2.6	-	-	1.8
RED HILL CREEK	205	2.7	1.3	0.9	2.8	2.8	2.7	2.5	2.0	NIS	NIS	NIS	NIS
HIGHVIEW	207	-	-	2.1	3.0	3.1	2.6	3.4	1.7	2.7	-	2.6	2.2
WHITNEY II	208	2.6	1.5	1.4	2.4	2.5	2.8	2.6	1.9	2.6	-	1.2	1.6
SAN DIEGO	209	-	1.9	2.2	2.8	2.3	2.3	2.5	2.1	NIS	NIS	NIS	NIS
UPPER OTTAWA	210	3.0	1.4	1.3	3.2	3.0	2.1	2.7	1.6	NIS	NIS	NIS	NIS

NIS = NOT IN SERVICE

McMASTER PSD SITES
MONTHLY MASS MEDIAN DIAMETERS
(MICRONS)

SITE NAME AND NUMBER		1983 MONTHS 01	02	03	04	05	06
MOUNT HOPE	201	2.1	3.0	2.9	2.7	3.9	3.0
BARTON AND SANFORD	202	3.1	3.8	3.5	3.8	4.5	4.2
NORTH PARK	203	3.1	4.2	2.9	3.6	4.7	4.2
SENECA	204	1.9	2.1	3.0	2.9	3.2	3.1
RED HILL CREEK	205	NIS	NIS	NIS	NIS	2.9	3.2
HIGHVIEW	207	2.3	2.8	3.4	2.9	3.3	3.3
WHITNEY II	208	2.1	1.8	2.6	2.4	3.0	2.9
SAN DIEGO	209	NIS	NIS	NIS	NIS	3.0	2.7
UPPER OTTAWA	210	NIS	NIS	NIS	NIS	2.9	3.2

NIS = NOT IN SERVICE

Appendix 3-3

ABSTRACT OF PRESENTATION ON INDOOR AIR QUALTIY STUDY RESULTS

Appendix 3-3

ABSTRACT OF PRESENTATION ON INDOOR AIR QUALITY STUDY RESULTS

Abstract for

Ontario Ministry of the Environment Technology Transfer Meeting

Tuesday, November 29, 1983

3:15 p.m.

THE HAMILTON STUDY: RELATIONSHIP BETWEEN OUTDOOR AND INDOOR AIR QUALITY IN HOMES AND ELEMENTARY SCHOOLS

L.D. Pengelly, W. Furlong, C. Goldsmith, and S. Toplack

Measurements have been made of indoor and outdoor levels of nitrogen dioxide (NO_2), sulphur dioxide (SO_2) and suspended particulate material (SPM) using a multipollutant sampler which we have developed (1). Observations were made for two 5-day sessions at each site, once during the heating season (H) and once during the non-heating season (NH). Paired indoor and outdoor observations were made during the same 24-hour sampling period at each site using the same instrumentation. Complete sets of paired data were obtained for 16 schools in both seasons, for 20 homes in the non-heating season and 14 of that 20 in the heating season. Data were much more difficult to obtain from homes than schools. The study showed patterns of results which were systematic for each pollutant, but differed between pollutants. Most of the results reported here will be in terms of indoor-outdoor ratio (I/O) expressed as percent, in the non-heating or heating season. For NO_2, in schools the I/O ratio was close to 75%, and was found to be independent of heating season, with indoor levels strongly correlated with outdoor levels. In homes, the I/O ratio depends on the presence of indoor sources, such as smokers, or gas stoves. In the absence of these, there is relatively little effect of heating season, and the ratio is about 80%. Smokers were not found to have an effect on indoor NO_2 levels in either season, but gas stoves were associated with markedly increased ($P < 0.001$) levels of NO_2 in both seasons, contributing an additional 13 ppb (NH) and 25 ppb (H). This resulted in homes with gas stoves having an I/O ratio of 1.8 (NH), 2.1 (H).

For SO_2, in schools, the I/O ratio was about 22%, independent of heating season, indoor levels being correlated with outdoor levels ($P<0.01$). In homes, the indoor level depends on heating season, and is poorly correlated ($P>0.05$) with outdoor levels in either season. The I/O ratio = 64% (NH), 15% (H) (SE 13%). For SPM, in schools, I/O ratio was 90% (NH), 140% (H), but there was no significant correlation with outdoor levels or season. In homes, I/O ratio was 134% (NH), 101% (H). In the non-heating season there was no significant correlation with outdoor levels, or the presence of smokers. In the heating season, there were significant effects from outdoor levels and smokers. The presence of smokers added 35 $\mu g/m^3$ of particulate to indoor levels.

The results of this study show that in schools, both for NO_2 and SO_2, indoor levels are well correlated with outdoor levels, independent of heating season, whereas indoor particulate levels are variable, frequently higher than outdoor levels, and uncorrelated with outdoor levels or heating season.

In homes without indoor sources for NO_2, there is little effect of heating season, and the indoor levels are correlated with outdoor levels. Gas stoves are a major indoor source, giving rise to indoor concentrations double the outdoor concentrations, during both heating and non-heating seasons. Levels of SO_2 are low indoors, poorly correlated with outdoor levels, and strongly dependent on heating season, being much lower during the heating season. Suspended particulate material levels indoors were generally higher than outdoors, and poorly correlated with outdoor levels in either season. During the heating season, however, the presence of smokers contributed substantially ($P<0.01$) to the particulate load, but had no effect on the NO_2 or SO_2 levels.

(1) Pengelly, L.D., A.T. Kerigan, C.H. Goldsmith, W. Furlong, W. Spurgeon, S. Toplack. A multipollutant sampler for indoor and outdoor ambient air. Proc. (Int.Symp. on Indoor Air Poll'n, Health and Energy Conservation) Session C2, No.11. Harvard Univ. JFK School of Gov't & School of Public Health. Amherst, Mass Oct. 13-16, 1981.

Appendix 4-1

DRAFT OF PAPER TO BE SUBMITTED TO JAPCA

THE HAMILTON STUDY: Distribution of Factors Confounding the Relationship Between Air Quality and Respiratory Health.

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Antony T. Kerigan Department of Medicine

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THE HAMILTON STUDY: Distribution of Factors Confounding the Relationship Between Air Quality and Respiratory Health.

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Introduction

It is generally accepted that the objective of air quality control is to preserve community health, and usually by this is meant community respiratory health. To this end it is important to establish relationships between degrees of respiratory health (or illness) and levels of pollutants in the ambient air. There have been many studies whose objective has been to establish these relationships; in the presence of severe air pollution, this task has not proven excessively difficult. However, in many jurisdictions where control measures have been in place for some time, and have proven effective, ambient air pollution levels have decreased substantially: in Hamilton, Ontario (Canada) for example, levels of SO_2 and coefficient of haze (COH) have fallen by more than an order of magnitude over the last two decades [1,2]. This has tended to shift the focus of air quality control and abatement from the problem of protecting the community from the acute health effects of protracted periods of severely elevated levels (a circumstance which now rarely occurs in Hamilton), to the long-term consequences of exposure to lower levels. It is postulated that long-term exposure to lower levels may produce subtle changes in the prevalence of chronic lung disease [3], and in this way produce its burden of ill health in the community. Although the attribution of acute respiratory ill health to severely elevated levels of air pollution has its own problems, the elaboration and understanding of the many factors which contribute to chronic lung disease is a task which is complex in itself; to clarify the role of ambient air quality among these factors is a difficult task which has only recently been undertaken systematically.

One of the most useful approaches to this problem has been the technique of examining the respiratory health of a cohort of elementary schoolchildren. In the last five years there have been many reports of studies of this type, with much variety in design, both from the epidemiological and air quality points of view. The reason for the use of young (typically ages 6-12) children is a much better characterization of the environmental conditions in which the children have grown, either before or during the period of study. Using questionnaire or interview techniques, the period of residence, dwelling characteristics, and family health and socio-economic factors can be established, and thus a comprehensive environmental picture can be determined for each child. Where studies have been undertaken, at least some data have been available on ambient air quality. In contrast, in studies of adults, the prevalence and degree of chronic lung disease is influenced not only by the factors described above, but also by occupational and recreational exposure to toxic agents, and also by smoking. In addition, in adult subjects, an accurate history of area of residence as well as the other environmental factors is much more difficult to obtain, and reliable air quality data for most jurisdictions has only been available for the last two or three decades.

A common approach to the design of a schoolchildren cohort study is to identify cohorts in discrete geographical areas, usually towns or cities, where air pollution levels are expected to be substantially different, based on historical information of varying quantity and quality [5-13]. A comparison is made of the respiratory health of the children in the various areas, and if significant differences are present, they may be ascribed to the differences in air quality between the areas, if such exist. Care must be taken, however, that in a design of this type the effect of differences in covariables between areas is not overlooked, because one cannot assume that the characteristics of these covariables are uniformly distributed throughout the population. The purpose

of this communication is to describe a study of a cohort of elementary school-children in which the distribution of these covariables among the areas of study has been examined.

Method

A cohort of 3200 children, aged 7-10 years was obtained by a random selection of 30 out of the 80 elementary schools in the Board of Education of the City of Hamilton, in September, 1978. Once a school was selected all the children meeting the age criterion in grades 2, 3, and 4 became eligible for inclusion. The parents of the children were interviewed personally and responses obtained via questionnaire to questions concerning the respiratory health of the selected child, his or her siblings, and of the parents themselves. Questions concerning smoking habits in the home, as well as residential and socio-economic factors thought to be of environmental significance were also asked, and consent obtained for the child to perform pulmonary function testing in the schools. The response rate (no. tested/no. eligible) was over 95%. The study continued for 3 years with the same children retested each year; in the second year an additional cohort of children were included in the study. We recognized that the random selection procedure had excluded any children from the industrial region of the city with poorest air quality, and three schools were added from this area, bearing in mind that they were not randomly selected.

Exposure Estimation

Air pollution measurements were obtained from a network of 30 hi-vol samplers for total suspended particulate (TSP) and 9 hi-vol samplers with Andersen 5-stage cascade impactors to determine mass median diameter (MMD). Samplers were operated for 24 hours according to the North American synoptic 6-day cycle. The geographical location (grid co-ordinates) of each sampler was determined, and the geometric mean of TSP values obtained for each site was calculated on a monthly basis. From monthly mean values for all sites, a response surface was calculated which represented at any given point on a vertical axis, TSP concentration, and on the other two, its geographical location in "easting" and "northing" co-ordinates. Thus from this surface, for the month for which the surface was generated, an estimate of the level of TSP could be obtained for any location within the city, and the degree of confidence of the estimate could also be given. From other information we determined that 90% of the children in the study lived within 1 km. of their school; thus we calculated exposure levels based on the location of the school each child attended. The ambient air pollution exposure for each child was calculated from an arithmetic average of 12 months exposure, determined from the values for that school 9 months before, two months after and including the month in which the child was tested. Because air quality measurements started at the same time as the epidemiology, adequate exposure data existed corresponding only to the second year of the study, in which the same child was tested for a second time. Information from the network of Andersen cascade impactors was handled in a similar way to TSP, except that, instead of concentration, aerodynamic mass median particle diameter (MMD) was calculated using standard methods from the 5 size fractional loadings, and these data averaged to give a monthly MMD value. Monthly values were then converted via response methodology to estimated monthly MMD at each school.

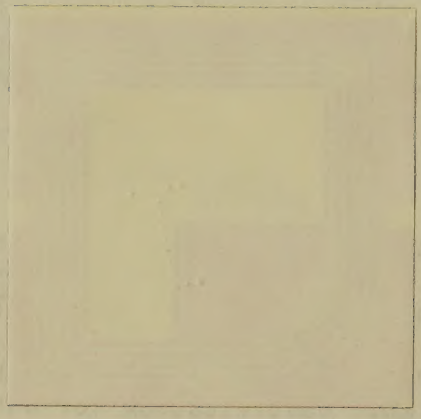
In our original design for the study, we did not have the benefit of comprehensive air quality data for the city, with which to establish the distribution of pollution with a great degree of accuracy or resolution. Thus we proposed (on the basis of historical data, as well as the results of a pilot study[14]) to divide the city into 4 'quadrants'. The basis for this division was a geographical one: the Niagara escarpment divides the city by a 100 metre discontinuity into "upper" (south) and "lower" (north) city areas. A major north-south street divides the city into east and west sections. Major industry (including 2 large steel mills) is located in the east lower quadrant. We expected air quality to be best in the west upper quadrant (WU) and poorest in the east lower (EL), with intermediate levels in the other quadrants. Because of the addition of the 3 schools in the second year of the study, we further identified a sub-area of the EL quadrant in which these schools were located, describing it as the Industrial Core (IC). The initial epidemiological design of the study ensured that, in each quadrant (except for IC) there would be 800 children, giving the total of 3200 in the first year. This sample size was determined on the basis of estimates of variability of our health outcome measurements, as found from our pilot study [14].

Covariables

It is not the purpose of this communication to describe the relationships found between air quality, other environmental covariables, and the health outcome measurements we observed from this study. These relationships will be the subject of further communications. Thus we will describe here only the distribution of the covariables we examined over the geographical areas of the city we studied. Justification for our selection of the covariables is provided from reports in the literature. There have been a number of reports of an association between respiratory morbidity and tobacco smoking in the home [15,19], and with the use of gas for cooking [13,16,18]. There has been described an association between respiratory morbidity and respiratory symptoms in other family members, particularly parents [8,20,21] and siblings [20,21]. Association between current respiratory morbidity and respiratory disease in infancy has also been described [22]. The effect of crowding in the home or bedroom has been studied previously [8,9,18,23], as has the effect of income and/or social/occupational status [8,18,10,14,25,13]. In addition, we have examined the distribution of air quality as indicated by TSP and MMD, as well as the distribution of length of period of residence in the areas. Analysis of data entered onto computer files has been by SPSS (Statistical Package for the Social Sciences, SPSS Inc. Suite 3000 444N. Michigan Ave. Chicago, IL 60611) implemented on the McMaster University Faculty of Health Sciences Hewlett-Packard 3000 computer, System III.

Results

Data presented here are from the second year of the study. For logistical reasons the study year did not coincide with the school year, and Year II of the study went from January - December 1980. The results presented were obtained from 3553 children studied in that year. In Table I the results of the analysis are given; in all instances except for the number in the group, and the socioeconomic status code, the results are expressed as prevalence in percent in the residential area defined by the column label. It is clear that in this sample, the industrial core has the highest prevalence of gas stove use, smoking in the home, parental cough, chest illness in siblings,



hospitalization for respiratory disease in infancy, crowding, low income and low occupational status, as well as highest ambient pollution levels. The east and west upper city areas have generally the lowest prevalence of these factors, as well as the best air quality. In those cases where prevalence was examined in the different areas, the chi-squared (X^2) test of the distribution was carried out, and in all cases there were significant differences ($P<0.01$) among areas. For continuously distributed variables (such as TSP) analysis of variance was used to determine if the differences between areas was significant, and was found so ($P<0.01$) in all cases. In Table II we have ranked the areas according to prevalence, or to some index of prevalence or the magnitude of a variable. From this, a pattern in the ranking of the areas is easy to observe, and for most covariables the ranking is surprisingly uniform. The Blishen [26] occupational code takes into account the 'status' of a job as well as its other more obvious attributes, and the code ranges from 10.00 (menial jobs) to 70.00 (high-status jobs).

Conclusions

In a study of environmental factors and respiratory health in elementary schoolchildren living in different areas of the same city, a set of covariables was identified which have previously been shown to influence respiratory health. It was found that the prevalence or magnitude of these covariables was not uniformly distributed among these areas across the city, nor were the characteristics of air quality which were measured. In addition, the patterns of prevalence which were found among the areas, of covariables which could influence respiratory health, tended to occur in the same direction, such that the effects of the covariables tended to reinforce each other. In studies of the effect of environmental factors on the respiratory health of schoolchildren reported in the literature, the effects of some of these covariables on the associations examined have been reported. We have not been able to find evidence that all the covariables that we have reported have been looked at together in the same study. Furthermore, in many studies, whether an effect of the covariable has been found or otherwise, the distribution of the prevalence or magnitude of that covariable throughout the cohort has not been reported. Although simple logic would lead one to predict that many of these covariables would share the same distributions throughout the cohort, there is little reported data to confirm this prediction. The statistical tests we have used so far have simply confirmed that the covariables we have examined are nonuniformly distributed throughout the cohort, but do not allow us to say that the distributions are the same (within certain limits of tolerance). Other analyses in our study, however, show strong associations between smoking in the home, parental cough, and infant illness. Although we have not yet formally tested it, one could postulate a relationship between low income, crowding in the home, use of gas stoves, illness of siblings, and low occupational status, on basic sociological grounds. A high illness rate in siblings is likely a reflection of crowding, a factor known to facilitate the spread of respiratory infections. The association of a high prevalence of gas stove use with living in the industrial core reflects the historical fact that coal gas was once used for cooking, and it was a by-product of the coke ovens in the industrial area. Our preliminery analysis, as well as the opinion of most residents of the city would have led us to expect the highest levels of TSP in the industrial core. Although the whole of the lower city had levels in excess of that of the upper city, the west lower quadrant had higher levels than the east lower. This probably reflects the fact that, when a condition of poor air quality arises in Hamilton,

it is usually associated with a lake-breeze inversion and light north-easterly winds. This carries emissions from the industrial area in a south-westerly direction and may possibly explain the elevated levels in the west lower area of the city. Dustfall, however, drops out closer to the source, and the industrial core looks dirtier for that reason. This probably also explains the trend for larger particle size in the industrial core.

It is clear that in the analysis of the data for the main study of which this a part, due care must be given to the presence of the common pattern in the distribution of the covariables. We were prepared for this problem, on the basis of the experience of others, and thus we acquired what information we could reasonably afford on the nature and extend of possible confounding covariables. We were surprised, however, at the strength and uniformity of the common patterns we found, and felt it worthy of report.

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Table I Prevalence of Covariables in Areas (%).

	WU[a]	EU	WL	EL	IC	
NUMBER IN SAMPLE	829	878	741	863	242	(TOTAL = 3553)
SMOKING IN HOME	56	62	62	70	81	
GAS COOKING	9	8	31	16	44	
MOTHER COUGH	15	15	18	18	29	
FATHER COUGH	22	26	26	26	40	
CHEST ILLNESS IN SIBLINGS	8	10	9	11	14	
RESPIRATORY HOSPITAL ADMISSION AS INFANT	6	6	9	8	13	
MORE THAN 5 PEOPLE IN HOUSE	17	13	19	17	31	
SHARE BEDROOM WITH 2 OR MORE	3	4	7	7	9	
LESS THAN 3 YEARS RESIDENCE	21	29	39	39	45	
IN LOWEST INCOME CLASS	16	11	21	16	26	
VALUES BELOW ARE MAGNITUDES, NOT GIVEN AS PREVALENCE.						
BLISHEN OCCUPATIONAL CODE	48	44	44	41	37	
TSP ($\mu g/m^3$)	~~45~~ 43	~~47~~ 43	~~65~~ 61	~~58~~ 60	~~61~~ 93	misprint?
MMD (μm)	2.7	2.5	2.5	2.6	3.1	

[a] for explanation of abbreviations, see text.

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